GM/DELPHI FUEL CELL DEVELOPMENT PROGRAM

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SUMMARY

The GM/Delphi Fuel Cell Program has completed 24 months of a planned 30 month activity. The deliverable of this Phase II effort is a 30kW system operating with a methanol reformer due by the end of July, 1997. Participants include the Delphi Automotive Systems Group, Delco Electronics, Ballard Power Systems, DuPont, and General Motors Research and Development Lab.

Technical achievements over the last twelve months of effort include scale up design, construction, and initial testing of a methanol reformer, design and construction of H_2, CO, and humidity sensors, thermal management design, along with compressor specification and procurement. In addition, single cell scale up and early short stack testing has occurred to evaluated cell design and MEA construction practices for the Delphi stack. System control electronics have been built and initial control strategies defined and implemented.

Ballard has supplied one 30kW stack in November 1995 and early results showed 34kW on synthetic reformate. Work continues on the GEN II stack to be delivered in late 1996.

DuPont has supplied membrane in both the catalyzed state and non-catalyzed state for evaluation. DuPont continues to show progress in the development of MEA process development. The development and supply of "1135" Nafion has been the result of system level trade-offs for performance and handling of product in a manufacturing environment.

In addition to the technical achievements, the program was relocated from Los Alamos National Laboratory to the new Delphi Fuel Cell Technical Center located in Rochester, New York. This also included installation of both large scale (60kW) test stands, along with facilities to test both single and short stack hardware. Construction and funding of this development site was done by the Delphi Energy and Engine Management Systems group.

SYSTEM EFFORT

During the last two months of 1995 a catalyzed heat exchanger was evaluated for the preferential oxidation of CO in the 10kW system at Los Alamos. Results of this testing indicated that a more stable and consistent oxidation process was achieved as compared to the previous staged adiabatic approach. An improved design utilizing gaseous cooling will be incorporated into the 30kW system.

System modeling studies were conducted to determine the relative merits of several system configurations and operating conditions. Systems operating at high and low pressure, high and low temperature, with and without an expander were considered. The results of these studies helped to define the system configuration and operating conditions for the 30kW deliverable. Additionally, a transient model for the methanol fuel processor subsystem has been developed.

An automotive electronic control module (ECM) has been developed and built to control the system. Software control algorithms will be developed, tested, and incorporated into the ECM during the remaining months of the program.

The majority of sensors for system control have been defined, developed and built. A prototype compressor and drive motor for initial system integration has been specified and will be delivered in October. Specification and procurement of the required oxidant and thermal system components is underway and will be completed during the remainder of this year.

FUEL PROCESSOR EFFORT

Efforts over the past twelve months have been centered around the fabrication of the methanol reformer and combustor. The fabrication of the reformer is complete and fabrication of the combustor is near completion.

Initial testing of the reformer is planned for the end of September 1996. Integration of the combustor is to take place during October 1996 and a combustor heated reformer is to be tested in the mid to late October time frame.

The reformer design was based on both recirculating and tubular style reactors. This was done to make the most effective use of both catalysts and heat transfer. The recirculation fan is powered directly by a 1.5 kW brushless DC motor with a maximum speed of 10,000 RPM. The heat from the combustor is introduced via a gas-to-gas heat exchanger. Once the combustor is integrated into the reformer (mid to late October), the shift reactor, if needed, will be sized, fabricated, and installed. As soon as the CO concentration from the reformer and shift is determined, the PrOx will be sized using a predetermined catalyst and integrated into the fuel processor subsystem.

Initially, the combustor for the system was a diffusion flame, pre-mix, pre-vaporized style. It was discovered through testing that operating this type of combustor reliably over a system turn down ratio of 5:1 was difficult at best. In the interest of time and operating simplicity, the decision was made to pursue a catalytic type of combustor. The catalytic combustor is more robust and significantly easier to control. Two catalytic combustors are being fabricated, one that will be used for further development in the combustor test stand and the other for initial development in the reformer. The combustor in the test stand will be able to handle transients as well as both liquid methanol and hydrogen fuels. This combustor will be integrated into the system in the next several months.

STACK EFFORT

The Delphi stack has been designed. Components for the stack are presently being fabricated. MEAs have been fabricated in sizes up 540 cm^2. Single cell testing has verified the performance of low catalyst loaded MEAs on large cells. In the course of evaluating many candidates for coating the bipolar plates, a low cost alternative to PVD processing has been identified.

A stack test facility has been installed and is now operational. It is capable of testing stacks up to 60 kW on H_2 or synthetic reformate fuels.

The Ballard activity has been focused on improved power density of the GEN II stack. This stack will be designed to operate on reformate and less than 3 bar air pressure. The first Ballard stack (GEN I) has been successfully tested on the Delphi 60kW test rig and is now being readied for development use in the initial system. The GEN I stack will be used to debug both control and hardware issues in this first system. It will be then replaced with the improved power density Ballard GEN II stack early in 1997.

FUTURE EFFORT

The remaining development activity will involve the system integration of the developed sub-system components into an operational 30kW stand alone unit. This activity will include integration of both the Ballard and Delphi stack, PRDA compressors, sensors, controls, and thermal management system. The intent of this deliverable is to move the technology one step closer to a transportation application using liquid fuel. This activity will be completed in fiscal year 1997.